

# Nutritional Characteristics and Preservation Methodologies of Tempeh

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Tempeh, a white pie-shaped fermented soybean food, is broadly consumed by people in Indonesia and other regions in Southeast Asia. It tastes soft and slimy, smells like yeast and cheese, and has a firmer texture than general fermented soybeans. The nutritional value of tempeh is tremendous. It has been known as the “alternative of meats” and the beloved vegetarian food. Since the 1960s, scientists from Southeast Asia and the United States has been researching and analyzing on tempeh’s benefits on human health. It has been discovered that tempeh is not only rich in peptides, free fatty acids, soluble minerals, vitamin B, and a strong antioxidant capability, but also prominent in producing a certain amount of vitamin B12, which does rarely exist in vegetarian food, through fermentation. As a matter of fact, vitamin B12 is an important elements in preventing vegetarians from atherosclerosis which mostly caused by “high homocysteine”.

In recent years, the study on isoflavones, anticancer capability, and antithrombotic function of tempeh has been focused internationally. Currently, tempeh has become very popular in Europe and America. Chinese people’s interest on this non salt-fermented soy product has also been gradually increasing.

## 1. Major nutritional elements and characteristics of tempeh

Since tempeh is produced by microbial fermenting soybean, its nutritional structure is very similar to soybean. Through fermentation, certain amount of nutrients have been altered.

**Table 1.** Nutrition facts of tempeh

Nutrient	Amount Per 100g	% Daily Value
Calories	230kcal	11.5%
Protein	21g	35%
Polyunsaturated fats	8g	—
Monounsaturated fats	3g	—
Total Carbohydrate	7g	2.3%
Total Dietary Fiber	7g	28%

Soluble Dietary Fiber	6.1g	—
Sugars	0g	0%
Sodium	15mg	0%
Potassium	210mg	10.5%
Calcium	114mg	14.3%
Cholesterol	0mg	0%
Vitamin B12	0.26µg	10.8%
Soy Isoflavones	32.76mg	—

**Data source:** PONY, government-oriented professional testing institution. Report ID: 1001281-240

**Table 2.** Nutrition comparison between tempeh and other soy based products

Nutrient	Amount Per 100g in Tempeh	Amount Per 100g in Tofu	Amount Per 100g in Dried Tofu	Amount Per 100g in Soymilk	% Daily Value
Protein	21g	8.1g	16.2g	1.8g	60g
Unsaturated Fats	11g	2.9g	2.8g	0.5g	—
Saturated:Unsaturated Fats	1:5.5	1:4.8	1:5.6	1:2.5	—
Dietary Fiber	7g	0.4g	0.8g	1.1g	25g
Sodium	15mg	7.2mg	76.5mg	3mg	2000mg
Potassium	210mg	125mg	140mg	48mg	2000mg
Calcium	114mg	164mg	308mg	10mg	800mg
Vitamin B12	0.26µg	—	—	—	2.4µg

**Data Source:**

1. Chinese Nutrition Society “Chinese Nutrition Facts 2004”
2. PONY, government-oriented professional testing institution. Report ID:1001281-240
3. Beijing Institute of Nutrition Source Test Report

### 1.1 Protein and Amino Acids

The protein that is in tempeh is called complete protein, it contains essential types of amino acids which are needed by human bodies. Therefore, it could be the supplement of other food that

lacks of lysine, the alternative of meat, and an excellent source of protein. Comparing to other non-fermented soy products, the amount of protein in tempeh does not change much. However, there are highly active proteases produced during the fermentation. Because of proteases, peptide, the intermediate hydrolyzed protein, small peptides that contains two to three amino acids, and free amino acids are significantly increased. Peptides are easily digested and absorbed, and also act like living cells in several ways. Thus, they can promote energy metabolism, increase muscle strength, improve immunity, as well as lower cholesterol, anti-thrombotic and anti-oxidation.

Whole cooked soybeans could provide a digestibility rate of protein for 60% to 65%, 85% for cooked soymilk, and over 93.8% for tempeh by nitrogen metabolism experiments on rats. Comparing to non-fermented soy products, tempeh has extra characteristics such as easy digestibility and improvement on gasless intestines. Therefore, tempeh helps people who suffer from gastrointestinal weakness and elderly's meet their health demands.

## **1.2 Lipids and Unsaturated Fatty Acids**

During the process of fermentation, lipases are produced by the bacteria in tempeh. Also, triglycerides are decomposed to free fatty acids, which further reduce body fat level as a carbon source. On the other hand, the oleic acid, linolenic acid, linoleic acid and other unsaturated fatty acids are increased by a significant amount. Oleic acid, the monounsaturated fatty acid in tempeh, has the ability of lowering the level of low-density lipoprotein cholesterol in human plasma and increasing the level of high-density lipoprotein cholesterol, which helps better off blood vessels problems. In addition, linoleic and linolenic acids are crucially essential for human bodies which could be only supplied by food ingestion and could not be produced by human bodies themselves. These essential fatty acids, which are also known as "body oil", can not only keep skin moisture, but also prevent water loss.

The natural antioxidants in tempeh can inhibit activity of cholesterol synthesis enzyme, reduce hepatically synthesized cholesterol, prevent the oxidation of LDL cholesterol, and thereby decrease the chance of having arterial plaque.

## **1.3 Minerals and Vitamins**

In the fermentation process, the minerals in tempeh transform to plasma state from combined state. At the same time, the amount of soluble mineral content increases significantly. For instance, soluble iron content rises from 24.29% to 40.52% which further suggests that the ability of absorption of iron is increased expressively. Thus, it is extremely helpful for people who have diseases caused by lacking of iron.

Because of the metabolism of fungi and bacteria, the level of vitamin B2, vitamin B6, niacin acid, folic acid and other vitamins B are increased greatly. Among all the vitamins produced, vitamin B12 is a particularly rare and helpful nutrient.

Lacking of vitamin B12 in long terms could lead one to have a dangerous condition called "megaloblastic anemia". Furthermore, a large number of cases and studies have confirmed that atherosclerosis and other cardiovascular and cerebrovascular diseases are mainly caused by low vitamin B12 level.

Homocysteine is transformed from dietary methionine in human bodies. However, it could not be further metabolized unless there is folic acid, which requires Vitamin B12 in participation. Therefore, when there is no Vitamin B12, the metabolizability of homocysteine would be weakened, the level of serum homocysteine would be raised, and the risk of having arteriosclerosis would be increased. This is the mechanism of arteriosclerosis caused by high homocysteine.

Vitamin B12 approximately exclusively comes from animal food. Thus, for vegetarians, lacking of vitamin B12 is a common situation. The adequate intakes (AI) for adults on Vitamin B12 that the Chinese Nutrition Society recommends is 2.4 $\mu$ g. In every 100g of tempeh produced in China, there is 0.26 $\mu$ g of vitamin B12. However, research team from Cornell University has claimed that there should be 8.8 $\mu$ g of vitamin B12 in every 100g of tempeh produced in the USA typically, which is 2.9 times the amount recommended daily. Though it is important that tempeh is critically helpful for prevention of high homocysteine, production of tempeh needs to be improved so that the level of vitamin B12 in it would be efficiently increased.

#### **1.4 Soy Isoflavones and Total Isoflavones**

Soy isoflavones exist in two forms, soy isoflavones glycosides (97%~98%) and soy isoflavones aglycones (2%~3%). Although soy isoflavones have significant capabilities of preventing tumors, oxidation, osteoporosis, and also increasing resilience, they are not in the best active condition. However, soy isoflavones aglycones are playing a crucial role improving their active condition by providing stronger antioxidant activity and higher biological activity. Isoflavones aglycones are isolated and increased during the fermentation of tempeh by its glycosylation enzymes.

Total isoflavones, another extract of tempeh, reflects a strong antibacterial ability against food spoilage bacteria and pathogens (staphylococcus aureus glucose, salmonella, bacillus subtilis, and Escherichia coli, etc.). In Indonesia, people normally use it to treat intestinal discomfort, because the white fungus in fresh tempeh are superiorly effective. Moreover, there are a lot of other cases about tempeh curing people such as it has been used to treat many British and Dutch soldiers during the WWII.

#### **1.5 Tempeh Kinase**

Tempeh kinase, a functional component of tempeh bacteria, has a substantial ability of dissolving blood clots and improving arteriosclerosis.

In 1980, Dr. Hiroyuki Sumi, who worked on research of blood clots in Robbins Institution of Research, Chicago, found out that among more than 230 kinds of food, nattokinase could directly decompose thrombosis and keep decomposing for 8 to 12 hours. On the other hand, urokinase could only keep working for 30 minutes. Moreover, nattokinase could be either administered orally or injected through skin whereas urokinase could only be taken by injection. Nattokinase could also work in capillaries. Likewise, tempeh could safely and effectively decompose blood clots, clean atherosclerotic plaque on blood vessel walls, and improve atherosclerotic as well. In addition, tempeh kinase could break down blood cholesterol and triglycerides and thus stable blood pressure and prevent cardiovascular diseases.

## **1.6 Anti-nutritional Components**

Trypsin inhibitor, lectins, phytic acid, and other anti-nutritional elements are removed during the production of tempeh. Phytase, which is produced in fermentation, lowers the level of phytic acid by 30.7% and thereby increases the bioavailability of the minerals.

## **2. Preservation and Consumption Guide**

### **2.1 Shelf Life**

Inactivated tempeh: 9 days refrigerated, 90 days frozen.

Activated tempeh: 7 days refrigerated, 60 days frozen

### **2.2 Preservation Methods**

The proper way of preserving tempeh is refrigeration. Freezing is required for longer term storage. Frozen tempeh has a dark color which is normal and could be consumed. Little change of odor would occur when storing tempeh for a relatively long period of time. This may affect the taste but is still consumable.

### **2.3 Recommended Way of Consumption**

Tempeh could be consumed individually, or cooked with other products such as cereals, potatoes, vegetables, fruits, edible mushrooms, meats, eggs, or fish. Tempeh is easy to cook because it has a firm texture and does not fall apart when boiling. Also, the white voids in tempeh could absorb soup and make the dish more delicious. It goes along with any cooking methods including steaming, boiling, frying, stewing, stir-frying and mixing like salad. Inactivated tempeh could be consume raw or cooked whereas active tempeh is suggested to be eaten raw or cold cooked, because heat would sabotage its enzymes substances.

## **3. Conclusion**

Tempeh is a soy-based microbial fermented food that contains essential nutrients that human body needs. It is delicious, inexpensive, nutritious, and could be easily cooked in all kinds of ways. The main driver of tempeh being rich of uniquely precious nutrients is its special way of production which is the fermentation. There are a lot of bacterial enzymes generated and free amino acids, free fatty acids, soluble minerals and various vitamin B increased in glycolysis of tempeh. Most importantly, vitamin B12, which does not exist in vegetarian food products, tempeh kinase, soy isoflavones aglycones, and other biologically active substances are produced. Moreover, anti-nutritional substances are removed during the processes. Besides all the general physiological functions owned by soybeans, tempeh also has additional ability of improving digesting, absorbing nutrition, adjusting proportion of low-high density lipoprotein cholesterol levels in plasma, stabiling blood pressure, lowering blood sugar, preventing cardiovascular diseases, as well as capabilities of anti-bacterial, anti-mutation, and anti-tumor. In a conclusion, it is extremely important for China to develop and improve on industrial production of tempeh because it helps vegetarians improve their dieting systems and furthermore health conditions

significantly.

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